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(54) **Abrasion-resistant flame-retardant composition.**

- (57) An abrasion-resistant composition comprising :
- (I) 100 parts by weight of a polymer component containing :
    - (A) 50-90% by weight, based on the total polymer weight, of a polyolefinic resin having a maximum peak temperature (T<sub>m</sub>) of higher than 125 °C as measured by differential scanning calorimetry (DSC), and
    - (B) 10-50% by weight, based on the total polymer weight, of a polyethylenic resin or rubber having a maximum peak temperature (T<sub>m</sub>) of lower than 125 °C as measured by DSC ; and
  - (II) 30-200 parts by weight of an inorganic flame retardant,  
said polymer component (I) containing 10<sup>-8</sup>-10<sup>-3</sup> gram equivalent based on 1 g of the polymers,  
of at least one functional group selected from :
    - a : carboxyl group, an ester group thereof, or an anhydride group thereof,
    - b : epoxy group,
    - c : hydroxyl group,
    - d : amino group,
    - e : alkenyl cyclic imino ether group and
    - f : silane group.

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Background of the Invention

The present invention relates to a flame-retardant composition which is superior in abrasion resistance. The invention further relates to a coating material or insulating material using the said flame-retardant composition. More particularly, the present invention is concerned with an abrasion-resistant flame-retardant composition which does not evolve a poisonous gas such as halogen gas during combustion and which has an anti-dripping property based on the formation of char, which retains flexibility, mechanical characteristics and resistance to chemicals and is superior in heat resistance. The present invention is further concerned with a coating material or insulating material using the said flame-retardant composition for coating or insulating electric wires and cables, for coating electric wire or cable, protecting pipes or joint covers, or for coating or insulating electric components and devices such as cabinets, boxes and sheets.

Polyolefin resins, because of their superior physical and chemical properties, are general-purpose resins which are in the greatest demand and which are applied to many domestic and industrial uses after being formed into films, sheets, pipes, containers, electric wires, cables, etc. by various molding methods, including extrusion and injection molding.

Since such polyolefin resins are easily flammable, various methods for making them flame-retardant have heretofore been proposed.

Of those methods, one which is adopted most commonly involves the addition of an organic flame retardant such as a halogen or phosphorus-based organic flame retardant to the polyolefin resins.

Although even a small amount of such organic flame retardant is effective, there is a drawback that a harmful gas is evolved during combustion.

Recently, in view of the above point, various methods have been studied (see Japanese Patent Laid Open Nos JP 2-53845A and 2-145632A in which hydrates of inorganometallic compounds such as aluminum hydroxide and magnesium hydroxide are used as low smoking, pollution-free type flame retardants not evolving a harmful gas during combustion).

In a flame-retardant composition using an inorganic flame retardant it is necessary to use the inorganic flame retardant in a high ratio in order to enhance the flame retardancy of the composition. However, increasing its content makes a practical use of the composition difficult because of deterioration in mechanical strength, flexibility and processability of the composition. To remedy this drawback there also has been proposed a technique of incorporating a high concentration of a soft polyolefin resin in the composition to increase the amount of such inorganic flame retardant accepted (see U.S. Patent Nos. 4,722,959 and 4,845,146).

However, in the case where a flame-retardant composition containing a large amount of such soft resin is used in the production of such electrically insulated materials as electric wires and cables, such electric materials as protective pipes and joint covers, such interior materials as sheet and floor material, or such molded articles as cabinets and boxes, the products are apt to have external flaws caused by friction under severe conditions involving extremely high temperatures, severe vibrations during production, transport and use. Therefore, the improvement of abrasion resistance has been desired.

And to this end, there have been proposed a method of improving the abrasion resistance by crosslinking in the presence of a crosslinking aid (Japanese Patent Laid Open Nos. JP 62-252442A and 62-275139A), a method of using an ethylene/ $\alpha$ -olefin copolymer modified with an unsaturated carboxylic acid or a derivative thereof (Japanese Patent Laid Open No. JP 2-10149A), and a method of using as a base polymer a mixture of a polyolefin resin with an ethylene resin containing carboxyl group or carboxylate in the molecule and a thermoplastic elastomer with maleic acid or maleic anhydride added in the molecule (Japanese Patent Laid Open No. JP 2-53845A). In all of these methods, however, there still remains room for improvement in point of processability and abrasion resistance, and a further improvement is desired.

It is the object of the present invention to provide an abrasion-resistant flame-retardant composition which has an improved heat resistance while retaining mechanical strength, flexibility, processability and flame retardancy and which can be used effectively in the production of molded articles, etc., including films sheets, containers, electric wires, cables, packing sealants, hoses and injection-molded products.

Summary of the Invention

The present invention resides in an abrasion-resistant flame-retardant composition comprising:

(I) 100 parts by weight of a polymer component containing:

(A) 50-90% by weight, based on the total polymer weight, of a polyolefinic resin having a maximum peak temperature ( $T_m$ ) of higher than 125°C as measured by differential scanning calorimetry (DSC), and

(B) 10-50% by weight, based on the total polymer weight, of a polyethylenic resin or rubber having a

maximum peak temperature ( $T_m$ ) of lower than 125°C as measured by DSC; and  
 (II) 30-200 parts by weight of an inorganic flame retardant, said polymer component (I) containing 10<sup>-3</sup>-10<sup>-3</sup> gram equivalent, based on 1 gram of the polymers, of at least one functional group selected from:

- a: carboxyl group or an anhydride group thereof,
- b: epoxy group,
- c: hydroxyl group,
- d: amino group,
- e: alkenyl cyclic imino ether group, and
- f: silane group.

#### Detailed Description of the Invention

The present invention will be described in detail hereinafter.

The polyolefinic resin having a maximum peak temperature ( $T_m$ ) of at least 125°C as measured by differential scanning calorimetry (DSC), which is used as component A) in the present invention, is preferably at least one of polyethylenes having a density of at least 0.94 g/cm<sup>3</sup> and homopolymers and copolymers (both will sometimes be hereinafter referred to together as "(co)polymer"). The "polyethylenes having a density of at least 0.94 g/cm<sup>3</sup>" indicate high density polyethylenes prepared by a medium or low pressure polymerization according to a liquid phase process or a vapor phase process, using a known Ziegler type catalyst. Examples of such polyethylenes include ethylene homopolymer, copolymers of ethylene and  $\alpha$ -olefins having 3 to 12 carbon atoms, and mixtures thereof. As examples of  $\alpha$ -olefins there are mentioned propylene, 1-butene, 4-methyl-1-pentene, 1-hexene, 1-octene and 1-dodecene.

Examples of C<sub>3</sub> to C<sub>12</sub>  $\alpha$ -olefin (co)polymers include homopolymers and intercopolymers of such  $\alpha$ -olefins as propylene, 1-butene, 4-methyl-1-pentene, 1-hexene, 1-octene and 1-dodecene, and ethylene as a comonomer. Above all, polypropylene, poly-1-butene, poly-4-methyl-1-pentene are preferred.

It is desirable that the melt flow rate (MFR) of such  $\alpha$ -olefin (co)polymers be selected from the range of 0.01 to 20 g/10 min., more preferably 0.1 to 10 g/10 min., still more preferably 0.5 to 7 g/10 min. If MFR is lower than 0.01 g/10 min., the processability will be deteriorated, and an MFR of higher than 20 g/10 min. will result in poor abrasion resistance.

The polyethylenic resin or rubber having a maximum peak temperature ( $T_m$ ) of not more than 125°C as measured by differential scanning calorimetry (DSC), which is used as component B) in the present invention, is preferably at least one of (B1) low-density polyethylenes of 0.86 to less than 0.94 g/cm<sup>3</sup> in density prepared by a high pressure radical polymerization process or low-density ethylene/ $\alpha$ -olefin copolymers of the same density range, (B2) ethylene-vinyl ester copolymers, (B3) ethylene/ $\alpha$ , $\beta$ -unsaturated carboxylic acid alkyl ester copolymers and (B4) rubbers.

The low-density polyethylenes prepared by a high pressure radical polymerization process or ethylene/ $\alpha$ -olefin copolymers, of 0.86 to less than 0.94 g/cm<sup>3</sup> in density, as (B1), indicate low-density polyethylenes (LDPE) of 0.86 to less than 0.94 g/cm<sup>3</sup> in density prepared by a high pressure radical polymerization process and ethylene/ $\alpha$ -olefin copolymers prepared by a medium or low pressure process using a Ziegler catalyst or any of other known methods, including very low density polyethylenes (VLDPE) of 0.86 to less than 0.91 g/cm<sup>3</sup> in density and linear low density polyethylenes (LLDPE) of 0.91 to less than 0.94 g/cm<sup>3</sup> in density.

Examples of suitable  $\alpha$ -olefins include propylene, 1-butene, 4-methyl-1-pentene, 1-hexene, 1-octene and 1-dodecene.  $\alpha$ -olefins having 3 to 10 carbon atoms are preferred, e.g. 1-butene, 4-methyl-1-pentene, 1-hexene and 1-octene with 1-butene being particularly preferred.

The  $\alpha$ -olefin content in the ethylene copolymer is preferably in the range of 5 to 40 mole%.

The VLDPE indicates a polyethylene having a density of 0.86 g/cm<sup>3</sup> to less than 0.91 g/cm<sup>3</sup>, a maximum peak temperature ( $T_m$ ) of higher than 100°C as measured by differential scanning calorimetry (DSC), a boiling n-hexane insolubles content of higher than 10 wt%, and exhibiting properties intermediate between the linear low-density polyethylene and the ethylene/ $\alpha$ -olefin copolymer rubber.

More particularly, the VLDPE is a copolymer of ethylene and an  $\alpha$ -olefin having 3 to 12 carbon atoms and it is a resin having both a highly crystalline portion which LLDPE exhibits and an amorphous portion which the ethylene/ $\alpha$ -olefin copolymer rubber exhibits. Mechanical strength and heat resistance which are characteristics of the former and self-tack, rubbery elasticity and low-temperature impact resistance which are characteristics of the latter, are present together in a well-balanced state. These characteristics are extremely useful in the present invention.

The VLDPE having such characteristics can be prepared using a catalyst system which is a combination of a solid catalyst component containing at least magnesium and titanium with an organoaluminum compound.

The ethylene-vinyl ester copolymers (B2) are copolymers prepared by a high pressure radical polymerization process. They comprise ethylene as a main component and vinyl ester monomers such as vinyl propionate, vinyl acetate, vinyl caproate, vinyl caprylate, vinyl laurate, vinyl stearate and vinyl trifluoroacetate. Ethylene-vinyl acetate copolymer, especially a copolymer comprising 50-99.5 wt% of ethylene, and 0.5-50 wt% of vinyl acetate is preferred.

Examples of the ethylene/ $\alpha,\beta$ -unsaturated carboxylic acid alkyl ester copolymers (B3) include ethylene/ $\alpha,\beta$ -unsaturated carboxylic ester copolymers and their metallic salts, amides and imides. They are preferably prepared by a high pressure radical polymerization process. Examples are ethylene-methyl (meth)acrylate copolymer and ethylene-ethyl (meth)acrylate copolymer. Especially, ethylene-ethyl acrylate copolymer (EEA), such as a copolymer comprising 50-99.5 wt% of ethylene, and 0.5-50 wt% of ethyl acrylate is preferred.

Examples of the rubbers (B4) include ethylene propylene rubber, butadiene rubber, isoprene rubber, natural rubber, nitrile rubber and isobutylene rubber. These rubbers may be used alone or in combination.

Examples of the ethylene propylene rubber include a random copolymer (EPM) containing ethylene and propylene as main components, and a random copolymer (EPDM) containing a diene monomer (e.g. dicyclopentadiene or ethylidene norbornene) as a third component in addition to ethylene and propylene.

Examples of the butadiene rubber, which indicates a copolymer containing butadiene as a constituent, are styrene-butadiene block copolymer (SBS), styrene-butadiene-ethylene copolymer (SBES) as a hydrogenated or partially hydrogenated derivative of SBS, 1,2-polybutadiene (1,2-PB), maleic anhydride-butadiene-styrene copolymer, and modified butadiene rubber having a core-shell structure.

Examples of the isoprene rubber, which indicates a copolymer containing isoprene as a constituent, are styrene-isoprene block copolymer (SIS), styrene-isoprene-ethylene copolymer (SIES) as a hydrogenated or partially hydrogenated derivative of SIS, and modified isoprene rubber having a core-shell structure.

Among those exemplified as component B), ethylenic polymer or rubber, in the present invention, ethylene-ethyl acrylate copolymer is most preferred.

It is desirable that the MFR of the ethylene-ethyl acrylate copolymer be selected from the range of 0.1 to 50 g/10 min., preferably 0.5 to 20 g/10 min. If the MFR is lower than 0.1 g/10 min., the fluidity of the resulting resin composition may be poor, and if it exceeds 50 g/10 min., there will arise deterioration of tensile strength, etc.

Preferably EEA has an EA content of 0.5-50 wt%, more preferably 5-30 wt% in view of economical reason and physical properties.

The functional group contained in the polymer component (I) in the present invention is at least one functional group selected from a: carboxyl group or an anhydride group thereof, b: epoxy group, c: hydroxyl group, d: amino group, e: alkenyl cyclic imino ether group and f: silane group. The functional group(s) may be introduced by introducing a monomer which contains the functional group into component A), component B) or both component A and component B by graft or random copolymerization. Further, the functional group(s) may be introduced by first introducing the functional group(s) into a part of component A), component B) or both component A and component B or a polymer other than components A) and B) in the same manner as above and then blending the graft modified polymer C) or random copolymerized polymer D with components A) and B). The latter is preferred. Preferred polymers to be grafted or random copolymerized include polyolefin resins or rubbers.

Examples thereof include graft-modified copolymers which at least one kind of monomer containing the functional group(s) is grafted to a polyolefinic resin or rubber, and a random copolymer in which at least one kind of monomer containing the functional group is copolymerized with a polyolefinic resin or rubber.

Examples of monomers which derive the functional group a: carboxyl group or an anhydride group thereof, include such  $\alpha,\beta$ -unsaturated dicarboxylic acids as maleic acid, fumaric acid, citraconic acid and itaconic acid, such unsaturated monocarboxylic acids as acrylic acid, methacrylic acid, furoic acid, crotonic acid, vinyl acetic acid and pentenoic acid, as well as esters and anhydrides of those monocarboxylic acids.

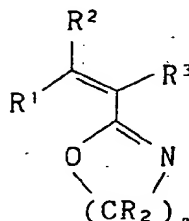
Examples of monomers which derive b: epoxy group include such glycidyl esters as glycidyl acrylate, glycidyl methacrylate, itaconic acid monoglycidyl ester, butenedicarboxylic acid monoglycidyl ester, butenedicarboxylic acid diglycidyl ester butenedicarboxylic acid triglycidyl ester, as well as glycidyl esters of maleic, crotonic and fumaric acids, such glycidyl ethers as vinyl glycidyl ether, allyl glycidyl ether, glycidyl oxyethyl vinyl ether and styrene-p-glycidyl ether, and p-glycidylstyrene. Particularly preferred are glycidyl methacrylate and allyl glycidyl ether.

Examples of monomers which derive c: hydroxyl group include 1-hydroxypropyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate and hydroxyethyl (meth)acrylate.

Examples of monomers which derive d: amino group include aminoethyl (meth)acrylate, propylaminoethyl (meth)acrylate, dimethylaminoethyl (meth)acrylate, diethylaminoethyl (meth)acrylate, dibutylaminoethyl (meth)acrylate, aminopropyl (meth)acrylate, phenylaminoethyl (meth)acrylate and cyclohexylaminoethyl (meth)acrylate.

(meth)acrylate.

Examples of monomers which derive : alkenyl cyclic imino ether group includ compounds represented by the following structural formula:



where n is 1, 2 or 3, preferably 2 or 3, more preferably 2, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R each represent an inert alkyl group having 1 to 12 carbon atoms and/or hydrogen, in which the alkyl group may contain an inert substituent group. The term "inert" as used herein means that no bad influence is exerted on graft reaction or the function of the resulting product. It is not necessary that all the Rs be the same. Preferably, R<sup>1</sup> = R<sup>2</sup> = H, R<sup>3</sup> = H or Me, R = H. That is, the monomers in question are 2-vinyl and/or 2-isopropenyl-2-oxazoline and 2-vinyl and/or 2-isopropenyl-5,6-dihydro-4H-1,3-oxazine. These may be used each alone or in combination. Particularly, 2-vinyl and/or 2-isopropenyl-2-oxazoline is preferred.

Examples of monomers which derive f: silane group, that is, as examples of unsaturated silane compounds, include vinyltrimethoxysilane, vinyltriethoxysilane, vinyltriacetoxysilane and vinyltrichlorosilane.

For incorporating the functional group(s) in the polymer component (I), as mentioned previously, there may be used a graft polymer in which at least one functional group is grafted to component A) or component B), or there may be used component B) which is in the form of a random copolymer containing the functional group(s). Or a mixture of those copolymers may be used.

In the case where a functional group-containing polymer C) or D) is blended with the components A) and B) to prepare the component (I), there may be used, a graft polymer with the functional group(s) grafted to component A) or B), or component B) which is in the form of a random copolymer containing the functional group(s), or a mixture thereof.

Also, the components A), B) and the functional group-containing compound can be blended in the presence of an organic peroxide and the like in an extruder to take place an addition reaction.

Among these functional group-containing polyolefinic resins, maleic anhydride-modified polyethylenes are most preferred.

According to a graft copolymer preparing method adopted in the present invention, the graft copolymer is prepared by subjecting at least one compound having the functional group(s) to a graft copolymerization in the presence or absence of a solvent and with or without a radical initiator, with the melting method being particularly preferred.

Examples of the radical initiator include organic peroxides, dihydroaromatic compounds and dicumyl compounds.

In the case of peroxide decomposing type polymers such as polypropylenes, since the polymer chain is cut by the peroxide, it is desirable to use a dicumyl compound or a dihydroaromatic compound as a relatively mild radical initiator.

Suitable examples of such organic peroxides are hydroperoxide, dicumyl peroxide, t-butylcumyl peroxide, dialkyl(allyl) peroxide, diisopropylbenzene hydroperoxide, dipropionyl peroxide, dioctanoyl peroxide, benzoyl peroxide, peroxy succinic acid, peroxyketal, 2,5-dimethyl-2,5-di-(t-butylperoxy)hexane, t-butyloxyacetate and t-butylperoxyisobutyrate.

Examples of the foregoing dihydroaromatic compounds include dihydroquinoline and derivatives thereof, dihydrofuran, 1,2-dihydrobenzene, 1,2-dihydronaphthalene and 9,10-dihydrophenanthrene.

Examples of the dicumyl compounds include 2,3-dimethyl-2,3-diphenylbutane, 2,3-diethyl-2,3-diphenylbutane, 2,3-diethyl-2,3-di-(p-methylphenyl)butane and 2,3-diethyl-2,3-di-(p-bromophenyl), with 2,3-diethyl-2,3-diphenylbutane being particularly preferred.

Examples of the inorganic flame retardant which is used as component (II) in the present invention, include aluminum hydroxide, magnesium hydroxide, zirconium hydroxide, basic magnesium carbonate, dolomite, hydrotalcite, calcium hydroxide, barium hydroxide, hydrate of tin oxide, hydrates of inorganometallic compounds e.g. borax, zinc borate, zinc metaborate, barium metaborate, zinc carbonate, magnesium-calcium carbonate, calcium carbonate, barium carbonate, magnesium oxide, molybdenum oxide, zirconium oxide and tin oxide.

These compounds may be used each alone or in combination of two or more. Above all, a hydrate of at least one metallic compound selected from aluminum hydroxide, magnesium hydroxide, zirconium hydroxide, basic magnesium carbonate, dolomite and hydrotalcite exhibits an excellent flame-retardant effect and is advantageous also from the economic point of view, with aluminum hydroxide and magnesium hydroxide being particularly preferred.

The particle diameter of the inorganic flame retardant differs depending on the kind thereof, but in the case of aluminum hydroxide and magnesium hydroxide, an average particle diameter is not larger than 20  $\mu\text{m}$ , preferably not larger than 10  $\mu\text{m}$ .

Red phosphorus employable in the present invention is preferably coated with an organic compound, an inorganic compound or both an organic compound and an inorganic compound.

Examples of such coated red phosphorus are those obtained by coating the surfaces of red phosphorus particles with thermosetting resins such as, for example, epoxy resins, phenolic resins, polyester resins, silicone resins, polyamide resins and acrylic resins, those obtained by coating the particle surfaces first with, for example, aluminum oxide, zinc or magnesium and then further with such thermosetting resins as just exemplified above, those obtained by first making the particle surfaces into a metal phosphide and thereafter coating them with the thermosetting resins, and those obtained by coating the particle surfaces with compound hydrated oxides of metals such as titanium, cobalt and zirconium. Thus, these modified forms of red phosphorus are mentioned as examples.

It is preferable that an average particle diameter of red phosphorus be in the range of 5 to 30  $\mu\text{m}$  and that the content of red phosphorus particles smaller than 1  $\mu\text{m}$  and those larger than 100  $\mu\text{m}$  be lower than 5 wt%. Further, it is preferred that in the case of a compound hydrated oxide of, for example, titanium and cobalt, the amount of deposited coating on the red phosphorus particle surface be in the range of 0.5 to 15 wt% as metal components (Ti + Co) based on the total weight and that likewise it be in the range of 0.1 to 20 wt% based on the total weight in the case of an organic resin coating.

Such modified red phosphorus is superior in thermal stability and resistance to hydrolysis, whereby a hydrolysis reaction in the presence of water or at a high temperature is prevented almost completely, and hence there will be no evolution of phosphine gas which is smelly and poisonous.

The amount of red phosphorus used is usually in the range of 0.1 to 20 parts by weight, preferably 0.2 to 15 parts by weight, based on 100 parts by weight of resin component. An amount thereof smaller than 0.1 parts by weight will be less effective, and even if red phosphorus is used in an amount exceeding 20 parts by weight, the flame retarding effect will not be improved any further and thus such amount is not desirable from the standpoint of physical properties and also from the economic point of view.

Examples of a crosslinking aid employable in the present invention include conventional polyfunctional compounds, such as polyfunctional methacrylate monomers typified by trimethylolpropane trimethacrylate, ethylene glycol dimethacrylate and diethylene glycol dimethacrylate, polyfunctional vinyl monomers typified by triallyl isocyanurate, diallyl phthalate and vinyl butyrate, bismaleimides typified by N,N'-m-phenylenebismaleimide and N,N'-ethylenebismaleimide, dioximes such as p-quinone dioxime, divinyl compounds such as divinylbenzene, 1,5-hexadiene-3-yne, hexatriene, divinyl ether and divinyl sulfone, allyl phthalate, 2,6-diacrylphenol and such diallyl compound as diallylcarbinol. Such conventional polyfunctional crosslinking aids are exemplified in various references such as I&EC PRODUCT RESEARCH AND DEVELOPMENT P202 VOL2 NO. 3 SEPTEMBER 1963.

The amount of the polyfunctional monomer used in the invention is usually in the range of 1 to 20, preferably 5 to 10, parts by weight relative to 100 parts by weight of resin component. If it is smaller than 1 part by weight, there may not be obtained a sufficient degree of crosslinking, and even if it exceeds 20 parts by weight, the degree of crosslinking will not be so high and thus such a large amount is rather uneconomical.

It is important for the composition of the present invention to contain components A), B) and (II), or components A), B), C) or D) and (II), and further contain in the polymer component  $10^{-8}$ - $10^{-3}$  g. equivalent, preferably  $10^{-7}$ - $10^{-4}$  g. equivalent, based on 1 g of the total polymers, of at least one kind of functional group selected from a to f. For incorporating such predetermined amount of the functional group in the polymer component, there may be used, as noted previously, a graft polymer with the functional group grafted to component A), component B), or both component A) and component B) or there may be used as component B) a random copolymer of ethylene and a monomer containing the functional group, or separately there may be used a functional group-containing polyolefinic resin or rubber which may be either component A) or B). Anyhow, it is important to control the content of the functional group so as to be  $10^{-8}$ - $10^{-3}$  g. equivalent per 1 g. of the total polymers.

In the case of a graft modified polyolefinic resin, the functional group content is usually in the range of  $10^{-8}$  to  $10^{-5}$  g. eq., preferably  $10^{-7}$  to  $10^{-6}$  g. eq.. If it is lower than  $10^{-8}$  g. eq., a coupling effect of the polymer components (I) and (II) and the inorganic flame retardant is difficult to be developed, while a graft modified

polyolefinic polymer having a functional group content exceeding  $10^{-5}$  g · eq. is difficult to be manufactured. In the case of a random copolymer with olefin, a suitable functional group content is usually selected in the range of  $10^{-6}$  to  $10^{-3}$  g · eq., preferably  $10^{-5}$  to  $10^{-4}$  g · eq.. If the content is less than  $10^{-6}$  g · eq., it will be difficult to attain a coupling effect of the resin component and the inorganic flame retardant, while as to a functional group content exceeding  $10^{-3}$  g · eq., not only it is difficult to produce a random copolymer having such a high content, but also there is a fear of deterioration in mechanical strength of the resulting composition.

In the present invention, "gram equivalent" means the number of moles of monomer which derives the functional group per 1 gram of the entire polymers contained in the composition.

In the composition of the present invention, components A) and B) are present in such proportions, based on the entire polymer component, as 50-10 wt% component B) relative to 50-90 wt% component A), preferably 40-20 wt% component B) relative to 60-80 wt% component A).

A proportion of component B) less than 10 wt% will result in a small amount of the inorganic flame retardant accepted, deterioration of mechanical strength and difficulty in enhancing the flame retarding effect. On the other hand, if it is more than 50 wt%, the proportion of the polyolefin resin as component A becomes smaller than 50 wt%, thus causing deterioration in processability, flexibility, abrasion resistance and heat resistance.

If the proportion of the inorganic flame retardant as component (II) is less than 30 parts by weight, it becomes necessary to use an organic flame retardant in combination with the inorganic flame retardant because with the latter alone it will be difficult to attain a satisfactory flame retardancy. On the other hand, a proportion thereof exceeding 200 parts by weight will result in deterioration of abrasion resistance and of mechanical strength, e.g. impact resistance loss of flexibility and poor low-temperature characteristics.

In the present invention, moreover the composition described above may be combined with an inorganic filler, whereby it is made possible to reduce the amount of the flame retardant used and impart other characteristics to the composition.

Examples of such inorganic filler include calcium sulfate, calcium silicate, clay, diatomaceous earth, talc, alumina, silica sand, glass powder, iron oxide, metal powder, graphite, silicon carbide, silicon nitride, silica, boron nitride, aluminum nitride, carbon black, mica, glass plate, sericite, pyrophyllite, aluminum flake, graphite, metal balloon, glass balloon, pumice stone, glass fiber, carbon fiber, whisker, metallic fiber, graphite fiber, silicon carbide fiber, asbestos and wollastonite.

These inorganic fillers may be used in an amount up to 100 parts by weight or so relative to 100 parts by weight of the composition of the present invention. An amount thereof exceeding 100 parts by weight is not desirable because mechanical characteristics, including impact strength, of molded articles obtained using the composition of the invention will be deteriorated.

In the case of using any of the inorganic flame retardants or fillers exemplified above in the invention, it is desirable to treat, for example, coat, the surface thereof with a fatty acid such as stearic acid, oleic acid or palmitic acid, or a metallic salt thereof, or paraffin, wax, polyethylene wax, or modified compounds thereof, an organoborane or an organic titanate.

How to prepare the crosslinkable, highly flame-retardant composition superior in abrasion resistance of the present invention is not specially limited. There may be adopted any known method.

For example, components A), B), C) or D) (II), red phosphorus and a crosslinking aid, as well as other additives if necessary, are dry-blended by means of a conventional tumbler or the like, or melt-kneaded for uniform dispersion by means of a conventional kneading machine such as, for example, Banbury mixer, pressure kneader, kneader/extruder, twin-screw extruder or rolls, to produce a mixture of resin composition or a molded product thereof.

Subsequently, crosslinking is allowed to take place, which may be done by heating, or in warm water, or by the application of electron beam or high energy radiation. There may be adopted a method which affords a crosslinked product simultaneously with the production of the aforesaid mixture of resin composition or molded product.

How to effect crosslinking using the composition of the present invention is not specially limited. There may be adopted any of: a method using a crosslinking agent; a method involving the application of electron beam or such high energy radiation as  $\beta$ -ray or  $\gamma$ -ray; and an aqueous crosslinking method using a silane compound or a titanate compound.

It is desirable for the flame-retardant composition after crosslinking to have a gel content of not lower than 70%, more preferably not lower than 75%. If the gel content is lower than 70%, the effect of improvement in abrasion resistance, heat resistance and flame retardancy may be unsatisfactory. The higher the gel content, the more outstanding the said effect, which is desirable.

As the crosslinking agent there may be used, for example, a crosslinking agent based on a free radical mechanism such as an organic peroxide, a crosslinking agent for natural and synthetic rubbers such as a sulfur compound, or a silane compound. But in the case of a peroxide decomposing type polymer such as polypropylene

pylene, since the polymer chain is cut by the peroxid, it is desirable to use a relatively mild crosslinking agent such as, for example, a dicumyl compound or a dihydroaromatic compound.

The components of the composition of the present invention are considered to play the following roles:

5 The polyolefin resin as component A) having a maximum peak temperature ( $T_m$ ) of higher than 125 °C as measured by differential scanning calorimetry (DSC) plays the role of remarkably improving abrasion resistance and heat resistance.

10 The ethylene (co)polymer or rubber as component B) having a maximum peak temperature ( $T_m$ ) of lower than 125°C as measured by DSC plays the role of increasing the amount of the inorganic flame retardant accepted without deteriorating the mechanical strength and also functions to improve flexibility and impact resistance.

The inorganic flame retardant as component (II) plays the role of affording a non-halogen type flame-retardant composition.

15 Component A) or B) containing a functional group and a polyolefin resin or rubber containing a functional group as component C) or D) exhibit a coupling effect for the resin component and the inorganic flame retardant as component (II) and play the role of enhancing the compatibility of the resins with each other, improving mechanical strength, abrasion resistance, heat resistance and processability and further improving the anti-dripping property by the formation of char during combustion.

20 Red phosphorus plays the role of making the composition of the invention flame-retardant to a higher extent, and the crosslinking aid functions to enhance the crosslinking efficiency and thereby further improve the flame retardancy and abrasion resistance.

25 Within the range not impairing the physical properties of the flame-retardant composition of the present invention there may be added at least one kind of a flaw and whitening preventing agent selected from ① mineral oil, wax, paraffins, ② higher fatty acids and their esters, amides or metallic salts, ③ silicone and ④ partial fatty acid esters of polyhydric alcohols, fatty acid alcohols, fatty acids, fatty acid amides, alkylphenols or alkyl-naphthol alkylene oxide adducts, as well as organic fillers, antioxidants, lubricants, organic or inorganic pigments, ultraviolet inhibitors, dispersants, copper damage preventing agents, neutralizers, plasticizers, nucleating agents, etc.

#### [Examples]

30 The present invention will be described below concretely by way of examples, but it is to be understood that the invention is not limited by those examples.

#### [Resins and Materials used]

- 35 Component A)
- A1 : High density polyethylene (HDPE)  
(Density = 0.950 g/cm<sup>3</sup>, MFR = 1.0 g/10 min.,  $T_m$  = 129°C, a product of Nippon Petrochemicals Co., Ltd.)
- A2 : Polypropylene (PP)  
40 (Density = 0.90 g/cm<sup>3</sup>, MFR = 1.0 g/10 min.,  $T_m$  = 167°C a product of Nippon Petrochemicals Co., Ltd.)
- Component B)
- B1-1 : Low density polyethylene (LDPE)  
(Density = 0.922 g/cm<sup>3</sup>, MFR = 1.0 g/10 min.,  $T_m$  = 108°C, a product of Nippon Petrochemicals Co., Ltd.)
- B1-2 : Linear low density polyethylene (LLDPE)  
45 (Density = 0.922 g/cm<sup>3</sup>, MFR = 1.0 g/10 min.,  $T_m$  = 122°C, a product of Nippon Petrochemicals Co., Ltd.)
- B1-3 : Ethylene/1-butene copolymer (VLDPE)  
(Density = 0.900 g/cm<sup>3</sup>, MFR = 1.0 g/10 min.,  $T_m$  = 120°C, a product of Nippon Petrochemicals Co., Ltd.)
- B2 : Ethylene/vinyl acetate copolymer (EVA)  
(VA content = 10 wt%, MFR = 1.0 g/10 min.,  $T_m$  = 97°C, a product of Nippon Petrochemicals Co., Ltd.)
- 50 B3 : Ethylene/ethyl acrylate copolymer (EEA)  
(EA content = 10 wt%, MFR = 0.4 g/10 min.,  $T_m$  = 104°C, a product of Nippon Petrochemicals Co., Ltd.)
- B4 : Ethylene/propylene copolymer rubber (EPR)  
(Propylene = 27 wt%, MFR = 0.7 g/10 min.,  $T_m$  = 67°C, EPO7P, a product of Japan Synthetic Rubber Co., Ltd.)
- 55 Component C)
- C1 : Maleic anhydride-modified ethylene/butene-1 copolymer (MANLL)  
(Density = 0.92 g/cm<sup>3</sup>, MFR = 1.2 g/10 min., Reacting weight of maleic anhydride = 0.2 wt%, a product of Nippon Petrochemicals Co., Ltd.)



- C2 : Alkenyl cyclic imino ether-modified ethylene-butene-1 copolymer (hereinafter referred to as "Alkenyl")  
(Density = 0.92 g/cm<sup>3</sup>, MFR = 1.2 g/10 min., Reacting weight = 0.2 wt%, a product of Nippon Petrochemicals Co., Ltd.)
- 5 C3 : Vinyltrimethoxysilane-modified ethylene-butene-1 copolymer  
(Density = 0.91 g/cm<sup>3</sup>, MFR = 1.2 g/10 min., Reacting weight = 0.2 wt%, a product of Nippon Petrochemicals Co., Ltd.)
- Component D)
- 10 D1 : Ethylene glycidyl methacrylate (E-GMA)  
(Density = 0.935 g/cm<sup>3</sup>, MFR = 4.0 g/10 min., GMA concentration = 10 wt%, a product of Nippon Petrochemicals Co., Ltd.)
- Component E)
- E1 : Magnesium hydroxide  
(Trade name: Kisuma 5J, a product of Kyowa Kagaku K.K.)
- 15 E2 : Aluminum hydroxide  
(Trade name: Higilite 42M, a product of Nippon Light Metal Company, Ltd.)
- Red Phosphorus  
Crosslinking Aid

## 20 Trimethylolpropane trimethacrylate (TMPT)

### (Testing Method)

- (1) Tensile Test (kg/cm<sup>2</sup>)(designated YTS, UTS) and  
Elongation (%)(designated UEL)
- 25 A test piece was obtained by blanking from a 1 mm thick sheet using No.3 dumbbell die, then subjected to measurement at a pulling speed of 200 mm/min. Using Tensilon.
- (2) Oxygen Index (OI)  
Determined according to JIS K7201.
- (3) Abrasion Resistance Test (ASTM C501-84)
- 30 After testing at 1,000 revolutions and at a load of 1 kg, using a Taber abrader, truck wheel H-22, a reduction in weight (mg) was measured.
- (4) Heat Deformation (Heat Resistance)  
Determined according to JIS C3005 and JIS C3605
- 35 (Temperature: 100°C, load: 3 kgf).

## Examples 1 - 104

After dry-blending compositions shown in Tables 1 to 8, the blends were each melt-kneaded and pelletized at a resin temperature of 200°C using a 50 mm dia. extruder, followed by pressing at 180°C, a pressure of 100 kg/cm<sup>2</sup>, for 5 minutes to obtain samples, which were then tested. The results of the tests are as set forth in Tables 1 to 8.

## Comparative Examples 1 - 5

45 Without using component A), the inorganic flame retardant of component E) was mixed with component B) in Comparative Example 1, while in Comparative Examples 2 to 5, the maleic anhydride-modified LLDPE (MANLL) of component C) and inorganic flame retardant of component E) were mixed with component B). Evaluation was made in the same way as in Example 1, the results of which are as shown in Table 9.

## 50 Comparative Examples 6 - 8.

In comparative Example 6, 95 wt% of HDPE was used as component A), and 5 parts by weight of MANLL of component C) and 100 parts by weight of the inorganic flame retardant of component E) were mixed with component A), while in Comparative Examples 7 and 8, HDPE was used as component A), MANLL was used as component C), 20 and 220 parts by weight of the inorganic flame retardant were used respectively. The results are shown in table 9. Evaluation was made in the same way as in Example 1, the results of which are as shown in Table 9.

## Comparative Examples 9 - 11

The procedure of Comparative Examples 6-8 was repeated except that PP was used as component A). The results of evaluation are as shown in Table 9.

## Comparative Examples 12 - 16

The procedure of Comparative Examples 1-5 was repeated except that red phosphorus was used. The results of evaluation are as shown in Table 10.

## Comparative Examples 17 - 19

The procedure of Comparative Examples 6-8 was repeated except that red phosphorus was used. The results of evaluation are as shown in Table 10.

## Comparative Examples 20 - 24

The procedure of Comparative Examples 1-5 was repeated except that a crosslinking aid was used. The results of evaluation are as shown in Table 10.

## Comparative Examples 25 - 27

The procedure of Comparative Examples 6-8 was repeated except that a crosslinking aid was used. The results of evaluation are as shown in Table 11.

## Comparative Examples 28 - 32

The procedure of Comparative Examples 12-16 was repeated except that a crosslinking aid was used. The results of evaluation are as shown in Table 11.

## Comparative Examples 33 - 35

The procedure of Comparative Examples 17 and 18 was repeated except that a crosslinking aid was used. The results of evaluation are as shown in Table 11.

## Examples 105 - 108

Using MAnLL, E-GMA, Alkenyl, VTMS as component (C) and E-GMA as components D), evaluation was made in the same manner as in Example 3, the results of which are as set forth in Table 12.

## Comparative Example 36

Without using component C), evaluation was made in the same manner as in Example 3, the results of which are as set forth in Table 12.

## Examples 1, 2, 3, 14, 15, 16, 109

Using 60-80 wt% of PP as component A) and 20-40 wt% of EEA or VLDPE as component B), evaluation was made in the same manner as in Example 1, the results of which are as set forth in Table 13.

## Comparative Examples 2, 6, 37 - 43

Using 0-100wt% of HDPE or PP as component A) and 0-100 wt% of EEA or VLDPE as component B), evaluation was made in the same manner as in Example 1, the results of which are as set forth in Table 13.

## [Effect of the Invention]

Since the flame-retardant composition of the present invention comprises a resin component as compo-

nent (I) and an inorganic flame retardant as component (II), the resin component (I) containing a specific amount of a specific functional group(s) and comprising components A) and B), the component A) being a polyolefin resin having a maximum peak temperature (T<sub>m</sub>) of higher than 125°C as measured by differential scanning calorimetry (DSC) and the component B) being an ethylene (co)polymer or rubber having a maximum peak temperature (T<sub>m</sub>) of lower than 125°C as measured by DSC, or it is a flame-retardant composition containing a specific amount of such functional group(s) in which is incorporated as component C) a polyolefin resin or rubber containing the functional group(s), there can be attained improvement of abrasion resistance and heat resistance while retaining flexibility, mechanical strength and high flame retardancy.

Particularly, the component A) contributes to the improvement of abrasion resistance and heat resistance because it is constituted by a crystalline resin, and the component B) enhances the receptivity of the inorganic flame retardant and can enhance the flame retarding effect without deterioration of mechanical strength and flexibility. The components A), B) and C), containing the functional group(s), play the role of coupling the resin component with the inorganic flame retardant or inorganic filler, enhance their mutual compatibility and improve mechanical strength, processability and abrasion resistance. They also contribute to the formation of char (a carbonized layer) during combustion and play the role of preventing dripping of the resins.

Thus, the resin composition of the present invention has a high flame retardancy, does not evolve such a poisonous gas as halogen gas during combustion, is superior in abrasion resistance and heat resistance and is also superior in safety, flexibility, mechanical characteristics, resistance to chemicals and electrical characteristics. Because of these excellent characteristics, the resin composition of the invention can be used for molding, for example, for the production of extrudates or injection-molded products, including films, sheets and pipes, further for electric wires and cables, and can be utilized in various fields, including the fields of fibers, electricity, electronics, automobiles, ships, aircraft, architecture and civil engineering.

Table 1

Example Nos. 1-13

	1	2	3	4	5	6	7	8	9	10	11	12	13
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LLDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR	20	30	40	40	40	40	30	30	30	10	30	10	30
C) C-1 MANLL (10-7g eq/g) C-3 alkenyl (10-7g eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
D) D-1 E-GMA (10-5g eq/g)							5 7.0						
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	100	100	100	100	100	100	100	100	100	100	100	100	100
MFR	0.20	0.25	0.27	0.21	0.22	0.23	0.24	0.26	0.24	0.30	0.25	0.21	0.22
YTS	130	128	125	126	124	128	130	126	126	127	126	128	127
UTS	120	124	125	127	132	125	127	130	128	127	128	120	124
UEL	500	460	400	450	410	420	400	490	400	420	450	410	460
OI	26.4	26.0	25.7	26.1	25.8	25.9	26.0	26.2	25.3	25.2	26.0	25.9	25.8
Abration Resistance mg	40	53	60	61	59	58	47	48	55	53	52	51	50
Heat Deformation %	4.2	5.3	5.6	5.5	5.3	5.0	4.6	5.0	4.8	4.7	5.1	5.5	5.2

Table 2

Example Nos. 14-26

	14	15	16	17	18	19	20	21	22	23	24	25	26
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LLDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR				40	40					30	10	30	10
C) C-1 MANLL (10-7g eq/g) C-3 alkenyl (10-7g eq/g)	20	30	40			40	30	30	30	10	30	10	30
D) D-1 E-GMA (10-5g eq/g)	5	5	5	5	5	5	5	5	5	5	5	5	5
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
MFR	100	100	100	100	100	100	100	100	100	100	100	100	100
YTS	0.21	0.25	0.27	0.20	0.21	0.23	0.24	0.26	0.22	0.23	0.21	0.22	0.24
UTS	137	135	130	128	128	129	133	127	129	129	130	131	129
UEL	120	123	125	126	130	123	125	128	126	123	124	127	125
OI	400	420	440	420	460	440	420	480	420	420	440	450	460
Abration Resistance mg	26.2	26.2	25.9	26.1	25.9	26.1	26.0	25.7	26.1	25.8	25.9	26.0	25.8
Heat Deformation %	38	50	57	50	42	40	41	58	52	49	51	50	49
	4.5	5.2	5.5	4.6	4.5	4.9	4.7	4.8	5.3	5.7	5.4	5.9	5.8

Table 3

Example Nos. 27-39

	27	28	29	30	31	32	33	34	35	36	37	38	39
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LLDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR	20	30	40	40	40	40	30	30	30	10	30	10	30
C) C-1 ManLL (10-7g eq/g) C-3 alkenyl (10-7g eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
D) D-1 E-GMA (10-5g eq/g)							5 7.0						
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	100	100	100	100	100	100	100	100	100	100	100	100	100
Red phosphorus	3	3	3	3	3	3	3	3	3	3	3	3	3
MFR	0.26	0.22	0.23	0.22	0.25	0.28	0.28	0.25	0.23	0.26	0.24	0.21	0.25
YTS	129	127	124	125	126	127	123	126	124	126	123	127	128
UTS	121	122	125	126	126	131	129	126	126	123	126	128	124
UEL	440	460	440	440	440	470	420	440	460	420	470	480	460
OI	29.4	29.3	29.3	29.9	29.2	29.5	29.2	29.7	30.3	29.8	29.5	29.6	29.8
Abration Resistance mg	43	55	61	59	48	49	57	54	56	53	51	58	56
Heat Deformation %	4.3	5.2	5.7	5.2	4.6	5.3	5.0	4.9	5.0	5.2	5.4	5.1	4.8

Table 4

Example Nos. 40-52

	40	41	42	43	44	45	46	47	48	49	50	51	52
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR	20	30	40	40	40	40	30	30	30	10	30	10	30
C) C-1 MANLL (10-7g eq/g) C-3 alkenyl (10-7g eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
D) D-1 E-GMA (10-5g eq/g)							5 7.0						
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	100	100	100	100	100	100	100	100	100	100	100	100	100
Red phosphorus	3	3	3	3	3	3	3	3	3	3	3	3	3
MFR	0.22	0.24	0.25	0.21	0.20	0.26	0.25	0.26	0.20	0.29	0.28	0.23	0.24
YTS	132	130	128	127	128	126	128	125	126	127	125	128	131
UTS	120	123	126	126	128	130	128	127	129	127	128	129	127
UEL	400	420	430	430	410	450	420	430	440	400	460	440	450
OI	30.2	30.4	30.6	30.4	29.9	30.3	30.0	30.1	30.0	30.4	30.1	30.2	29.9
Abration Resistance mg	39	43	55	53	47	45	51	50	52	51	52	56	51
Heat Deformation %	3.9	5.0	5.5	5.0	4.4	5.0	4.9	4.6	4.8	5.0	5.1	5.0	4.5

Table 5

Example Nos. 53-65

	53	54	55	56	57	58	59	60	61	62	63	64	65
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LLDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR	20	30	40	40	40	40	30	30	30	10	30	10	30
C) C-1 ManLL (10-78 eq/g) C-3 alkenyl (10-78 eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
D) D-1 E-GMA (10-58 eq/g)							5 7.0						
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	100	100	100	100	100	100	100	100	100	100	100	100	100
Crosslinking Aid	5	5	5	5	5	5	5	5	5	5	5	5	5
MFR	0.22	0.23	0.26	0.21	0.22	0.27	0.26	0.24	0.25	0.22	0.21	0.29	0.27
YTS	128	125	125	126	127	123	124	123	121	124	125	126	125
UTS	122	123	124	130	128	130	126	127	127	125	123	126	128
UEL	430	450	450	450	430	460	410	430	450	430	450	460	470
OI	26.2	26.6	26.4	26.8	26.3	26.3	26.2	26.6	26.3	26.6	26.4	26.7	26.4
Electron beam exposure Mrd	15	15	15	15	15	15	15	15	15	15	15	15	15
Abration Resistance mg	43	53	59	57	46	46	55	53	54	51	50	56	55
Gelation %	86	87	83	88	87	83	81	85	86	87	83	81	82
Heat Deformation %	3.1	3.9	4.4	4.1	3.2	4.3	4.0	3.7	4.2	4.3	4.3	4.3	3.9



Table 6

Example Nos. 66-78

	66	67	68	69	70	71	72	73	74	75	76	77	78
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LLDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR	20	30	40	40	40	40	30	30	30	30	10	30	10
C) C-1 ManLL (10-7g eq/g) C-3 alkenyl (10-7g eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
D) D-1 E-GMA (10-5g eq/g)							5 7.0						
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	100	100	100	100	100	100	100	100	100	100	100	100	100
Crosslinking Aid	5	5	5	5	5	5	5	5	5	5	5	5	5
MFR	0.23	0.26	0.22	0.24	0.22	0.24	0.23	0.28	0.25	0.23	0.24	0.21	0.27
YTS	131	129	127	128	130	127	125	126	123	123	127	126	128
UTS	122	121	124	125	124	132	125	124	128	121	123	126	124
UEL	410	420	410	420	400	430	410	460	460	410	440	460	470
OI	26.5	26.6	26.7	26.7	26.4	26.8	26.8	27.0	26.9	26.5	26.4	26.4	26.6
Electron beam exposure Mrd	15	15	15	15	15	15	15	15	15	15	15	15	15
Abration Resistance mg	35	40	53	50	44	41	48	50	50	49	50	52	49
Gelation %	82	83	81	86	86	85	83	85	85	82	84	85	82
Heat Deformation %	3.1	4.3	4.5	4.5	4.2	4.0	4.1	4.2	4.1	4.6	4.5	4.3	4.0

Table 7

	79	80	81	82	83	84	85	86	87	88	89	90	91
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LLDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR	20	30	40	40	40	40	30	30	30	10	30	30	10
C) C-1 MAnLL (10-7g eq/g) C-3 alkenyl (10-7g eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
D) D-1 E-GMA (10-5g eq/g)	100	100	100	100	100	100	100	100	100	100	100	100	100
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5
Red phosphorus Crosslinking Aid	0.24 130 120 420 29.4	0.21 125 124 440 29.3	0.24 123 125 450 29.5	0.20 125 129 410 29.5	0.24 128 125 440 29.1	0.25 122 131 470 29.7	0.22 121 124 430 29.5	0.23 123 126 430 29.1	0.22 124 126 410 29.6	0.20 126 125 450 29.9	0.23 127 127 460 29.1	0.23 124 124 450 29.3	0.25 124 124 410 29.6
MFR	15	15	15	15	15	15	15	15	15	15	15	15	15
YTS	42	52	55	53	44	42	54	51	53	50	49	54	53
UTS	83	84	80	85	85	87	88	82	83	85	89	83	86
UEL	3.2	3.8	4.3	4.0	3.3	4.1	4.2	3.5	4.1	4.3	4.0	4.1	4.1
OI													
Electron beam exposure Mrd													
Abration Resistance mg													
Gelation %													
Heat Deformation %													

Table 8

Example Nos. 92-104

	92	93	94	95	96	97	98	99	100	101	102	103	104
A) A1 HDPE A2 PP	80	70	60	60	60	60	70	70	70	60	60	60	60
B) B1-1 LDPE B1-2 LDPE B1-3 VLDPE B2 EVA B3 EEA B4 EPR	20	30	40	40	40	40	30	30	30	10	30	10	30
C) C-1 MAnLL (10-7g eq/g) C-3 alkenyl (10-7g eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
D) D-1 E-GMA (10-5g eq/g)							5 7.0						
E) E-1 Mg(OH) <sub>2</sub> E-2 Al(OH) <sub>3</sub>	100	100	100	100	100	100	100	100	100	100	100	100	100
Red phosphorus Crosslinking Aid	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5
MFR	0.28	0.25	0.24	0.25	0.23	0.22	0.25	0.27	0.22	0.26	0.28	0.22	0.26
YTS	132	120	128	129	132	124	127	128	126	124	126	128	130
UTS	126	123	124	122	121	130	128	123	127	123	126	123	121
UEL	400	410	410	410	410	440	420	440	440	470	450	450	410
OI	29.8	30.3	30.2	29.2	29.7	29.9	29.8	30.0	29.8	29.8	29.9	30.2	29.5
Electron beam exposure Mrd	15	15	15	15	15	15	15	15	15	15	15	15	15
Abration Resistance mg	36	39	50	53	45	44	45	51	52	47	51	53	50
Gelation %	80	81	88	83	82	88	83	81	83	86	86	81	86
Heat Deformation %	3.2	4.1	4.3	4.4	4.3	4.1	4.6	4.3	4.2	4.1	4.3	4.1	4.0

Table 9

Comparative Example Nos. 1-11

	1	2	3	4	5	6	7	8	9	10	11
A) A1 HDPE A2 PP						95	60	60	95	60	60
B) B1-3 VLDPE B2 EVA B3 EEA B4 EPR	100	100	100	100	100	5	40	40	5	40	40
C) C-1 MANLL (10-7g eq/g)		5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
E) E-1 Mg(OH) <sub>2</sub>	100	100	100	100	100	100	20	220	100	20	220
MFR	0.40	0.23	0.25	0.31	0.40	0.30	0.42	0.05	0.35	0.44	0.06
YTS	95	100	102	108	100	135	124	130	134	132	133
UTS	90	130	131	130	90	90	130	90	85	130	95
UEL	300	550	560	500	110	100	550	90	90	480	90
OI	26.0	26.1	26.5	25.5	24.5	24.9	19.8	29.8	24.7	19.9	30.5
Abration Resistance mg	200	190	195	190	180	40	45	50	39	43	48
Heat Deformation %	15.2	14.0	13.8	12.5	15.0	4.5	4.9	8.0	4.3	4.7	7.8

Table 10  
Comparative Example Nos. 12-24

	12	13	14	15	16	17	18	19	20	21	22	23	24
A) A1 HDPE A2 PP						95	60	60					
B) B1-3 VLDPE B2 EVA B3 EEA B4 EPR	100	100	100	100	100	5	40	40	100		100	100	100
C) C-1 ManLL (10-7g eq/g)		5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2		5 9.2	5 9.2	5 9.2	5 9.2
E) E-1 Mg(OH) <sub>2</sub>	100	100	100	100	100	100	20	220	100	100	100	100	100
Red phosphorus Crosslinking Aid	3	3	3	3	3	3	3	3	5	5	5	5	5
MFR	0.40	0.23	0.25	0.31	0.40	0.30	0.42	0.05	0.38	0.25	0.22	0.32	0.36
YTS	95	100	102	108	100	135	124	130	92	110	100	102	110
UTS	90	130	131	130	90	90	130	90	93	120	128	129	95
UEL	300	550	560	500	110	100	550	90	280	520	540	510	100
OI	29.6	30.3	29.9	30.5	30.1	24.6	19.1	38.7	26.3	26.1	26.0	26.1	26.2
Electron exposure Mrd									15	15	15	15	15
Abration Resistance mg	210	200	200	195	190	50	52	51	240	120	110	100	130
Gelation %									30	85	88	84	83
Heat Deformation %	15.5	14.7	14.1	12.4	16.0	4.4	5.1	8.4	13.5	11.4	10.1	10.2	10.3

Comparative Example Nos. 25-35

Table 11

	25	26	27	28	29	30	31	32	33	34	35
A) A1 HDPE A2 PP	95	60	60						95	60	60
B) B1-3 VLDPE B2 EVA B3 EEA B4 EPR	5	40	40	100	100	100	100	100	5	40	40
C) C-1 MANLL (10-7g eq/g)	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2
E) E-1 Mg(OH) <sub>2</sub>	100	20	220	100	100	100	100	100	100	20	220
Red phosphorus Crosslinking Aid	5	5	5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5
MFR	0.30	0.40	0.04	0.37	0.27	0.21	0.34	0.33	0.30	0.38	0.04
YTS	137	122	135	91	100	110	105	100	132	120	130
UTS	90	128	91	90	110	122	123	90	94	120	90
UEL	90	510	85	220	500	510	500	110	95	500	80
OI	26.2	18.5	38.2	29.1	29.2	30.1	29.5	29.8	29.9	18.1	39.3
Electron exposure Mrd	15	15	15	15	15	15	15	15	15	15	15
Abrasion Resistance mg	53	50	50	220	110	130	120	127	51	52	53
Gelation %	81	83	85	28	81	83	81	82	81	85	87
Heat Deformation %	4.2	5.3	10.3	13.8	12.4	11.1	10.7	10.0	4.4	5.0	10.1

Table 12  
Effects of Coupling Agent

	Ex. 105	Ex. 106	Ex. 107	Ex. 108	Com. 36
A) A1 HDPE	60	60	60	60	60
B) B3 EEA	40	40	40	40	40
C) C-1 MANLL (10-7g eq/g) C-2 Alkenyl (10-7g eq/g) C-3 VTMS (10-7g eq/g)	5 9.2		5 9.2	5 9.2	
D) D-1 E-GMA (10-5g eq/g)		5 7.0			
E) E-1 Mg(OH) <sub>2</sub>	100	100	100	100	100
Abration Resistance mg	60	70	75	95	200

Table 13

Influence of Composition

	Com. 37	Com. 38	Com. 6	Ex. 1	Ex. 2	Ex. 3	Com. 39	Com. 9	Ex. 14	Ex. 15	Ex. 16	Com. 2	Com. 40	Com. 41	Com. 42	Ex. 109	Com. 43
A) A1 HDPE A2 PP	100	100	95	80	70	60	100	95	80	70	60		30	20	10	60	40
B) B1-3 VLDPE B3 EEA			5	20	30	40		5	20	30	40	100	70	80	90	40	60
C) C-1 MAnLL (10-7g eq/g)		5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2	5 9.2		5 9.2	5 9.2
E) E-1 Mg(OH) <sub>2</sub>	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MFR	0.36	0.32	0.30	0.20	0.25	0.27	0.35	0.35	0.21	0.25	0.27	0.23	0.28	0.30	0.35	0.22	0.24
YTS	118	128	135	130	128	125	130	134	137	135	130	100	105	112	98	130	126
UTS	80	80	90	120	124	125	80	85	120	123	125	130	110	118	95	124	118
UEL	85	90	100	500	460	400	95	90	400	420	440	550	490	510	350	440	480
Abration Resistance mg	88	39	40	40	53	60	88	39	38	50	57	190	130	150	190	55	120



## Claims

- 5 1. An abrasion-resistant flame-retardant composition comprising:
  - (I) 100 parts by weight of a polymer component containing:
    - (A) 50-90% by weight, based on the total polymer weight, of a polyolefinic resin having a maximum peak temperature ( $T_m$ ) of higher than 125 °C as measured by differential scanning calorimetry (DSC), and
    - 10 (B) 10-50% by weight, based on the total polymer weight, of a polyethylenic resin or rubber having a maximum peak temperature ( $T_m$ ) of lower than 125°C as measured by DSC; and
  - (II) 30-200 parts by weight of an inorganic flame retardant, said polymer component (I) containing  $10^{-8}$ - $10^{-3}$  gram equivalent based on 1 g of the polymers, of at least one functional group selected from:
    - 15 a : carboxyl group or an anhydride group thereof,
    - b : epoxy group,
    - c : hydroxyl group,
    - d : amino group,
    - e : alkenyl cyclic imino ether group, and
    - 20 f : silane group.
2. The composition of claim 1, wherein said functional group is incorporated by graft-modification and is present in an amount of  $10^{-8}$ - $10^{-5}$  gram equivalent based on 1g of the polymers.
3. The composition of claim 1, wherein said functional group is incorporated by random copolymerization and is present in an amount of  $10^{-8}$ - $10^{-3}$  gram equivalent based on 1g of the polymers.
4. The composition of claim 2, wherein the graft modification is made by graft-modifying a polyolefinic resin or a rubber with a polymerizable monomer containing the functional group.
5. The composition of claim 3, wherein the random copolymerization is made by random copolymerizing ethylene and a polymerizable monomer containing the functional group.
6. The composition of any one of claims 1 to 5, further containing red phosphorus.
7. The composition of any one of claims 1 to 6, further containing a crosslinking aid.
8. The composition of any one of claims 1 to 7, wherein said component A) is at least one member selected from polyethylenes not lower than 0.94 g/cm<sup>3</sup> in density and  $\alpha$ -olefin (co)polymers having 3 to 12 carbon atoms.
9. The composition of claim 8, wherein said component A) is at least one member selected from high density polyethylenes (HDPE) and polypropylenes (PP).
10. The composition of any one of claims 1 to 9, wherein said component B) is at least one member selected from:
  - 45 (B1) a low density polyethylene prepared by a high-pressure radical polymerization process or an ethylene/ $\alpha$ -olefin copolymer, having a density in the range from 0.86 to less than 0.94 g/cm<sup>3</sup>;
  - (B2) an ethylene/vinyl ester copolymer;
  - (B3) an ethylene/ $\alpha,\beta$ -unsaturated carboxylic acid alkyl ester copolymer; and
  - (B4) rubber.
11. The composition of claim 10, wherein said component (B1) is a low density polyethylene prepared by a high-pressure radical polymerization process and having a density of 0.86 to less than 0.94 g/cm<sup>3</sup>, an ethylene/ $\alpha$ -olefin copolymer having a density of 0.86 to less than 0.91 g/cm<sup>3</sup>, or an ethylene/ $\alpha$ -olefin copolymer having a density of 0.91 to less than 0.94 g/cm<sup>3</sup>; said component (B2) is an ethylene/vinyl acetate copolymer; said component (B3) is an ethylene/ethyl acrylate copolymer; and said component (B4) is an ethylene/propylene copolymer rubber or an ethylene/propylene/diene copolymer rubber.
12. The composition of any one of claims 1 to 11, wherein said functional group is a carboxyl group or an acid

anhydride group.

13. The composition of claim 12, wherein said acid anhydride group is derived from maleic anhydride group.
- 5 14. The composition of claim 4, wherein the functional group-containing polymer is an ethylene/ $\alpha$ -olefin copolymer modified with a carboxyl group- or acid anhydride group-containing monomer and having a density of 0.86 to less than 0.97 g/cm<sup>3</sup>, or an ethylene/ $\alpha$ -olefin copolymer modified with an alkenyl cyclic imino ether derivative-containing monomer and having a density of 0.86 to less than 0.97 g/cm<sup>3</sup>.
- 10 15. The composition of claim 5, wherein the functional group containing polymer is an epoxy group containing ethylene copolymer.
16. The composition of any one of claims 1 to 15, wherein said inorganic flame retardant is a hydrate of an inorganic metallic compound.
- 15 17. The composition of claim 16, wherein said hydrate of the inorganic metallic compound is magnesium hydroxide, aluminum hydroxide or both magnesium hydroxide and aluminum hydroxide.
18. The composition of claim 1, wherein said component A) is at least one member selected from HDPE and PP; said component B) is at least one member selected from VLDPE, LLDPE, LDPE, EVA having a vinyl acetate content of 5-30% by weight and EEA having an ethyl acrylate content of 5-30% by weight; said functional group-containing polymer is an ethylene/ $\alpha$ -olefin copolymer modified with maleic anhydride and having a density of 0.86 to less than 0.97 g/cm<sup>3</sup>; and said inorganic flame retardant is at least one member selected from magnesium hydroxide and aluminum hydroxide.
- 20 19. The composition of claim 18, wherein said component A) is HDPE; said component B) is EEA having an ethyl acrylate content of 5-30% by weight; said functional group-containing polymer is an ethylene/ $\alpha$ -olefin copolymer modified with maleic anhydride and having a density of 0.86 to less than 0.97 g/cm<sup>3</sup>; and said inorganic flame retardant is magnesium hydroxide.
- 25 20. The composition of claim 18, wherein said component A) is PP; said component B) is EEA having an ethyl acrylate content of 5-30% by weight; said functional group-containing polymer is an ethylene/ $\alpha$ -olefin copolymer modified with maleic anhydride and having a density of 0.86 to 0.97 g/cm<sup>3</sup>; and said inorganic flame retardant is magnesium hydroxide.
- 30 21. The composition of any one of claims 1 to 20, which exhibits a reduction in weight of not more than 100 mg after testing at a load of 1 kg and 1,000 revolutions using a Taber abrader, truck wheel H-22.
- 35 22. A coating or insulating material comprising the abrasion-resistant flame-retarding composition of any one of claims 1 to 21.